

I claim:

1. Apparatus for making fused silica products, comprising a vacuum chamber, a support extending into the chamber, a first mover connected to the support for moving the first support with respect to the chamber, plural parallel substrates positioned in the chamber, second movers connected to the support and connected to the substrates for moving the substrates in the chamber with respect to each other, silica particle providers in the chamber for providing silica particles for depositing on the substrates, heaters in the chamber for heating the substrates and particles deposited thereon, thereby fusing particles on the substrates, wherein the heaters heat the fused particles and wherein other silica particles from the providers collect and stick on the particles and create preforms on the substrates.
2. The apparatus of claim 1, wherein the substrates comprise long hollow porous tubular substrates, and wherein the first and second movers rotate the long hollow porous tubular substrates within the chamber.
3. The apparatus of claim 2, wherein the heaters further comprise heaters within the hollow tubular substrates for heating the substrates.
4. The apparatus of claim 1, further comprising valved vacuum, dopant gas and purge gas ports connected to the chamber.
5. The apparatus of claim 1, wherein the substrates are hollow porous tubes, further comprising valved purge gas and dopant gas connections to the hollow porous tubes.
6. The apparatus of claim 1, wherein the silica particle providers comprise burners mounted near walls of the chamber for pyrolysis of silicon compositions for generating silica powder.
7. The apparatus of claim 1, wherein the silica particle providers comprise silica powder injectors near walls of the chamber.
8. The apparatus of claim 1, wherein the second movers further comprise rotation and translation mechanisms connected to the support for rotating and translating the substrates in

the chamber.

9. The apparatus of claim 1, wherein the second movers further comprise independent adjustment and support mechanisms connected to the support which are connected to the rotation and translation mechanisms, and further comprising plural adjusters connected to the independent rotation and support mechanism for moving the plural substrates and rotating them with respect to each other as the independent rotation and translation mechanisms rotate and translate the substrates within the chamber.

10. The apparatus of claim 1, further comprising heat controls connected to the heaters for increasing temperature within the chamber to vitrification temperatures for vitrifying and densifying the preforms in the chamber.

11. The apparatus of claim 1, wherein the chamber, the substrates and the preforms are vertically oriented, and wherein the particle providers provide particles from cylindrical side areas of the chamber.

12. The apparatus of claim 11, further comprising preform melting chamber below the preform forming chambers, and a movable shelf separating the preform forming chamber and the preform melting chamber, heaters adjacent the walls of the preform melting chamber and valved ports connected to the preform melting chamber for providing gas delivery, gas vent, vacuum and dopants, and wherein the heaters provide multiple heating zones in the chambers, and further comprising a rotating and pulling assembly connected to the preform melting chamber for withdrawing a fused silica member from the preform chamber.

13. The apparatus of claim 12, further comprising a plasma surface removal unit positioned below the rotating and pulling assembly for finishing a surface of the fused silica member.

14. The apparatus of claim 12, further comprising a plate and bar forming chamber having an input connected to the rotating and pulling assembly for withdrawing the fused silica member directly into the plate and bar forming chamber.

15. A fused silica producing apparatus, comprising a fused silica chamber having silica particle providers connected thereto for providing silica particles within the chamber, heaters within the chamber for heating the particles and fusing the particles, a crucible within the chamber for collecting the heated and fused particles, heaters connected to the crucible for heating and fusing the silica particles in the crucible, a valved dopant gas supplier connected to the crucible for supplying dopant gas to fused particles within the crucible, a melting zone connected to the crucible for delivering molten fused silica from the crucible, a shaped body positioned below the melting zone for controlling molten fused silica flow, and a purge gas connection connected to the forming member for introducing a purge gas in a middle of the molten flow, a plate and bar forming chamber connected to an output of the fused silica chamber for directly receiving a fused silica output therefrom.

16. The apparatus of claim 15, further comprising an electrical field generator having inner electrodes positioned beneath the forming body and outer electrodes positioned adjacent the flow for passing an electric field through the molten fused silica flow.

17. The apparatus of claim 15, further comprising a second crucible positioned below the melting zone of the first crucible for receiving molten fused silica, and a valved dopant gas inlet connected to the second crucible for introducing dopant gas into molten fused silica in the second crucible.

18. Quartz apparatus comprising a plate/bar fabrication vacuum chamber having a plurality of valved vacuum ports, gas inlet ports, vent ports, and a fused silica feed material introduction port, resistance or RF heating mounted in the chamber and connected to a power source through a plurality of feedthroughs, a crucible made from graphite, silicon carbide, ceramic material, metal or metal alloys for receiving the feed material from the introduction port, and for softening and solidifying the material, a plurality of ultrasound generators near the crucible for promoting proper mixing and outgassing of the material, and additional vacuum ports placed above the softened material in the crucible for removing any gas bubbles.

19. The apparatus of claim 18, wherein the fabrication chamber comprises a plurality of chambers.

20. A method of producing fused silica fiber optic preforms, comprising relatively rotating a plurality of substrates with respect to each other in a chamber, heating the chamber and the substrates, directing silica particles inward in the chamber toward the substrates, holding and fusing silica particles on the substrates, and sticking particles to particles held on the substrates and forming porous silica preforms on the substrates, and relatively moving the substrates and preforms with respect to the chamber.

21. The method of claim 20, wherein the directing the silica particles comprise generating silica particles with pyrolysis of silica particle precursors from wall-mounted burners.

22. The method of claim 20, further comprising directing silica particle streams toward the substrates and preforms.

23. The method of claim 22, further comprising providing dopant gases to the chamber and through the substrate, and providing purge gas to the chamber and through the substrate, and venting and removing gases from the chamber.

24. The method of claim 20, wherein the moving comprises relatively rotating and translating the substrates and preforms within the chamber.

25. The method of claim 20, further comprising stopping the particles, increasing heat on the preforms, and densifying and vitrifying the preforms.

26. The method of claim 25, further comprising depositing second layers of fused silica on the densified for vitrified silica preform.

27. The method of claim 20, further comprising a doped or undoped silica core on the substrate for depositing a doped or undoped cladding layer on the silica core.

28. An apparatus for forming a fused silica member, comprising an elongated chamber, having a pressure control connected to the chamber, controlling pressure in the chamber, at least one collector in the chamber, silica particle providers in the chamber for

supplying silica particles in the chamber and for directing the silica particles toward the collector.

29. The apparatus of claim 28, wherein the collector comprises at least one substrate in the chamber, a rotation assembly mounted on the chamber and connected to the at least one substrate for relatively rotating the substrate with respect to the chamber, at least one heater connected to the chamber for supplying heat to the collector and to the chamber for directing heat to the silica particles for softening surfaces of the particles, sticking the heated particles to the substrate and forming a porous preform of particles around the substrate and for sticking the heated particles to particles on a surface of the preform.

30. The apparatus of claim 29, wherein the pressure control comprises at least one reduced pressure port in the chamber for venting and withdrawing gas.

31. The apparatus of claim 30, further comprising at least one inlet port in the chamber for introducing purgant, dopant or oxidant gas into the chamber.

32. The apparatus of claim 28, wherein the substrate comprises a hollow and porous substrate, and further comprising a substrate gas inlet connected to the substrate, for introducing purgant or dopant gas into the substrate for flowing the gas out through the porous substrate and through the preform on the substrate.

33. The apparatus of claim 30, wherein at least one heater comprises at least one radiant heater in the chamber for directing heat to the substrate, the preform and the silica particles in the chamber.

34. The apparatus of claim 29, wherein at least one heater comprises a radio frequency heater in the chamber, for directing heat to the substrate, the preform and the particles in the chamber.

35. The apparatus of claim 29, wherein at least one heater comprises a substrate heater connected to the substrate.

36. The apparatus of claim 29, wherein at least one heater comprises plural heaters in the chamber for heating plural heat zones along the elongated chamber.

37. The apparatus of claim 29, further comprising a translation mechanism connected to the chamber and the substrate for relatively translating the substrate with respect to the chamber.

38. The apparatus of claim 29, wherein at least one substrate comprises plural parallel substrates mounted in the cylinder, and wherein the rotation assembly further comprises multiple rotator connectors for relatively rotating the substrates with respect to each other substrate.

39. The apparatus of claim 29, wherein the silica particle providers comprise burners for introducing and pyrolyzing compounds in the chamber for the silica particles in the chamber.

40. The apparatus of claim 29, wherein the silica particle providers comprise providing silica powder stream injectors in the chamber for directing preformed silica powder toward the substrate and preform.

41. The apparatus of claim 29, wherein the elongated chamber comprises a vertical elongated chamber, and wherein the at least one substrate is vertical within the chamber.

42. The apparatus of claim 41, wherein the rotation assembly further comprises a substrate support at a top of the chamber, and wherein at least one heater further comprises at least one heater for providing increased heat near a bottom of the chamber for softening and flowing fused silica from the preform.

43. The apparatus of claim 42, wherein at least one substrate further comprises an enlarged lower end for flowing softened fused silica from an outer surface of the preform around the enlarged lower end.

44. The apparatus of claim 42, further comprising a rotating and pulling mechanism near a lower end of the chamber for rotating and pulling the softened fused silica from the chamber.

45. The apparatus of claim 44, wherein the softened and fused silica is pulled from the chamber as a tube.

46. The apparatus of claim 44, wherein the softened and fused silica is pulled from

the chamber as a rod.

47. The apparatus of claim 44, wherein at least one heater further comprises a resistance heater connected to the substrate for softening fused silica in the preform adjacent the substrate.

48. The apparatus of claim 43, further comprising at least one divider partially extended across the chamber toward the substrate and the preform for separating an upper part of the chamber from a lower part of the chamber.

49. The apparatus of claim 43, wherein the divider is adjustable.

50. The apparatus of claim 43, wherein the divider is adjustable in extension outward and across the chamber.

51. The apparatus of claim 48, wherein the divider is adjustable upward and downward along the chamber.

52. The apparatus of claim 48, further comprising a first gas vent, a first vacuum port and a first dopant inlet connected to the chamber above the divider.

53. The apparatus of claim 52, further comprising a gas delivery system, a second gas vent, a second vacuum port and a second dopant inlet connected to the chamber below the divider.

54. The apparatus of claim 48, wherein the divider is movable between opened and closed positions and extends inward to near the substrate in the closed position, wherein the silica powder providers are positioned above the divider for growing the preform above the divider, wherein the at least one heater comprises at least one heater for increasing heating of the substrate above the divider, and wherein the divider in the opened position allows passage of the preform through the divider, whereby when the divider is moved to the opened position and the at least one heater increases temperature of the substrate above the divider, a portion of the preform near the substrate softens, allowing the preform to slide downward on the substrate and moving the preform from the upper part of the chamber to the lower part of the chamber.

55. The apparatus of claim 44, further comprising electrodes near the softened silica, an electric field generator connected to the electrodes, and an electric field in the softened silica.

56. The apparatus of claim 55, further comprising at least one of the electrodes on one side of the softened silica, at least one other of the electrodes on an opposite side of the softened silica, and the electric field through the softened silica.

57. The apparatus of claim 56, wherein the flowing of the softened silica from the preform comprises forming a tubular bubble and the at least one of the electrodes positioned outside of the tubular bubble, and the at least one other of the electrodes positioned within the tubular bubble.

58. The apparatus of claim 57, wherein the electrodes comprises concentric ring electrodes.

59. The apparatus of claim 42, further comprising a second chamber having a crucible tray for receiving the softened silica from the first chamber in the crucible tray, and heaters in the second chamber for heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

60. The apparatus of claim 59, further comprising ultrasound generators in the second chamber adjacent the crucible tray for outgassing gas from the softened reformed fused silica.

61. The apparatus of claim 60, further comprising additional vacuum ports near the crucible tray for removing gases outgassed from the softened reformed fused silica.

62. The apparatus of claim 28, wherein the silica particle providers are positioned in an upper part of the chamber for directing particles inward into a mass of particles, providing resistive, radio frequency, plasma or other heaters, heating particles and softening surfaces of the particles in the mass, and wherein the at least one collector comprises a first heated crucible positioned with respect to the mass of particles for collecting softened particles and agglomerations of softened surface particles in the first heated crucible, a lower heated throat on the first crucible, with a heater on the throat for softening, fusing and flowing fused silica from



the first crucible.

63. The apparatus of claim 62, further comprising a flow director mounted beneath the lower heated throat, for directing flow of the flowing fused silica as a tubular or solid member having round, rectangular or polygonal cross-section.

64. The apparatus of claim 63, further comprising a dopant injector connected to the flow director for supplying dopant to the flowing fused silica.

65. The apparatus of claim 64, further comprising a second crucible positioned below the heated throat, for receiving flowing fused silica, and a dopant injector in the second crucible for injecting dopant in the fused silica in the second crucible.

66. The apparatus of claim 64, further comprising a second chamber, a crucible tray in the second chamber, for receiving the softened silica from the first chamber in the crucible tray, a heater in the second chamber for heating the fused softened silica and for reforming the silica in a desired form in the crucible tray.

67. The apparatus of claim 66, further comprising ultrasound generators in the second chamber adjacent the crucible tray for outgassing gas from the softened reformed fused silica.

68. The apparatus of claim 67, further comprising additional vacuum ports near the crucible tray for removing gases outgassed from the softened reformed fused silica through the additional vacuum ports.

69. Apparatus for forming a fused silica member, comprising an elongated chamber, a pressure control connected to the chamber, controlling pressure in the chamber, at least one collector mounted in the chamber, silica particle providers connected to the chamber for supplying silica particles in the chamber and directing the silica particles toward the collector, at least one heater connected to the chamber for supplying heat to the collector and to the chamber and for directing heat to the silica particles for softening surfaces of the particles for sticking the particles on heated particles to the collector forming a porous preform on the collector and sticking the heated particles to a surface of the preform for collecting the particles with softened

surfaces with the collector.

70. The apparatus of claim 69, wherein the collector comprises at least one substrate in the chamber, a rotation assembly mounted on the chamber and connected to the at least one substrate for relatively rotating the substrate with respect to the chamber.

71. The apparatus of claim 70, wherein the pressure control comprises at least one reduced pressure port in the chamber and venting and withdrawing gas.

72. The apparatus of claim 70, further comprising at least one inlet port in the chamber for introducing purgant, dopant or oxidant gas into the chamber.

73. The apparatus of claim 70, wherein the substrate is hollow and porous, and further comprising a substrate gas inlet connected to the substrate for introducing purgant or dopant gas into the substrate and flowing the gas out through the porous substrate and through the preform on the substrate.

74. The apparatus of claim 70, wherein the at least one heater comprises at least one radiant heater in the chamber for directing heat to the substrate, the preform and the silica particles in the chamber.

75. The apparatus of claim 70, wherein the at least one heater comprises a radio frequency heater in the chamber for directing heat to the substrate, the preform and the particles in the chamber.

76. The apparatus of claim 70, wherein the at least one heater comprises a substrate heater connected to the substrate.

77. The apparatus of claim 70, wherein the at least one heater comprises plural heaters in the chamber for heating and forming plural heat zones along the elongated chamber.

78. The apparatus of claim 70, further comprising a translation mechanism connected to the chamber and the substrate for relatively translating the substrate with respect to the chamber.

79. The apparatus of claim 70, wherein the at least one substrate comprises plural

parallel substrates mounted in the chamber, and wherein the rotation assembly further comprises multiple rotator connectors for relatively rotating the substrates with respect to each other substrate.

80. The apparatus of claim 70, wherein the silica particle providers comprise burners for introducing and pyrolyzing compounds in the chamber for providing the silica particles in the chamber.

81. The apparatus of claim 70, wherein the silica particle providers comprise silica powder stream injectors in the chamber for directing preformed silica powder toward the substrate and preform.

82. The apparatus of claim 70, wherein the elongated chamber is vertical and the at least one substrate is vertical within the chamber.

83. The apparatus of claim 82, wherein the rotation assembly further comprises a substrate support at a top of the chamber, and wherein the at least one heater further comprises at least one heater for providing increased heat near a bottom of the chamber for softening and flowing fused silica from the preform.

84. The apparatus of claim 83, wherein the substrate further comprises an enlarged lower end for flowing softened fused silica from an outer surface of the preform.

85. The apparatus of claim 83, further comprising a rotating and pulling mechanism near a lower end of the chamber for rotating and pulling the softened fused silica from the chamber.

86. The apparatus of claim 85, wherein the softened and fused silica is pulled from the chamber as a tube.

87. The apparatus of claim 85, wherein the softened and fused silica is pulled from the chamber as a rod.

88. The apparatus of claim 85, wherein the at least one heater further comprises a resistance heater connected to the substrate for softening fused silica in the preform adjacent the

substrate.

89. The apparatus of claim 85, further comprising at least one divider partially extending across the chamber toward the substrate and the preform for separating an upper part of the chamber from a lower part of the chamber.

90. The apparatus of claim 89, wherein the divider is adjustable in and out across the chamber.

91. The apparatus of claim 89, wherein the divider is adjustable upward and downward along the chamber.

92. The apparatus of claim 89, further comprising a first gas vent, a first vacuum port and a first dopant inlet connected to the chamber above the divider.

93. The apparatus of claim 92, further comprising a gas delivery system, a second gas vent, a second vacuum port and a second dopant inlet connected to the chamber below the divider.

94. The apparatus of claim 93, wherein the divider is movable between opened and closed positions and extends inward to near the substrate in the closed position, wherein the silica powder providers are positioned above the divider for growing the preform above the divider, wherein the at least one heater comprises at least one heater for increasing heating of the substrate above the divider, and wherein the divider in the opened position allows passage of the preform through the divider, whereby when the divider is moved to the opened position and the at least one heater increases temperature of the substrate above the divider, a portion of the preform near the substrate softens, allowing the preform to slide downward on the substrate for moving the preform from the upper part of the chamber to the lower part of the chamber.

95. The apparatus of claim 83, further comprising electrodes near the softened silica and an electric field generator connected to the electrodes for providing an electric field in the softened silica.

96. The apparatus of claim 95, wherein at least one of the electrodes is on one side of

the softened silica, and wherein at least one other of the electrodes is on an opposite side of the softened silica for providing an electric field through the softened silica.

97. The apparatus of claim 96, wherein the softened silica flowing from the preform forms a tubular bubble, wherein the at least one of the electrodes is outside of the tubular bubble, and wherein the at least one other of the electrodes is within the tubular bubble.

98. The apparatus of claim 97, wherein the electrodes are concentric ring electrodes.

99. The apparatus of claim 85, further comprising a second chamber having a crucible tray for receiving the softened silica from the first chamber, and at least one second chamber heater in the second chamber for heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

100. The apparatus of claim 99, further comprising ultrasound generators in the second chamber adjacent the crucible tray for outgassing gas from the softened reformed fused silica.

101. The apparatus of claim 100, further comprising additional vacuum ports near the crucible tray for removing gases outgassed from the softened reformed fused silica.

102. The apparatus of claim 28, wherein the particle providers are positioned in an upper part of the chamber and are oriented for directing particles inward into a mass of particles, and wherein the at least one heater comprises a resistive, radio frequency, plasma or other heater for heating particles and softening surfaces of the particles in the mass of particles, and wherein the collector comprises a first heated crucible positioned with respect to the mass of particles for collecting softened particles and agglomerations of softened surface particles from the mass, the first heated crucible having a lower heated throat on the first crucible, with a heater on the throat for softening, fusing and flowing fused silica from the first crucible, a second chamber having a crucible tray for receiving the softened silica from the first chamber, and at least one second chamber heater in the second chamber for heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

103. The apparatus of claim 102, further comprising a flow director mounted beneath

the lower heated throat for directing flow of the flowing fused silica as a tubular or solid member having round, rectangular or polygonal cross-section.

104. The apparatus of claim 103, further comprising a dopant injector connected to the flow director for supplying dopant to the flowing fused silica.

105. The apparatus of claim 104, further comprising a second crucible positioned below the heated throat for receiving flowing fused silica, and a dopant injector in the second crucible for injecting dopant in the fused silica in the second crucible.

106. The apparatus of claim 105, further comprising a second heated throat on the second crucible for flowing fused silica out of the second crucible into the second chamber.

107. The apparatus of claim 102, further comprising ultrasound generators in the second chamber adjacent the crucible tray for outgassing gas from the softened reformed fused silica.

108. The apparatus of claim 107, further comprising additional vacuum ports near the crucible tray for removing gases outgassed from the softened reformed fused silica.

109. Method for making fused silica products, comprising providing a chamber, providing plural parallel substrates positioned in the chamber, providing a support, providing first movers on the support connecting the first movers to the substrates, moving the substrates with respect to each other, providing a second mover connected to a support for the first movers for moving the first mover with respect to the chamber, disposing silica particle providers in the chamber for providing silica particles which deposit on the substrates, providing heaters in the chamber, heating the substrates and the particles, softening and agglomerating surfaces of the particles and sticking the particles on the substrates and on particles stuck to the substrates and creating preforms of the particles on the substrates.

110. The method of claim 109, wherein providing the substrates comprises providing long hollow tubular substrates, and wherein the first and second movers rotate the long hollow tubular substrates within the chamber.

111. The method of claim 110, wherein providing the heater further comprise providing a heater within the hollow tubular substrates and heating the substrates from within.

112. The method of claim 110, further comprising connecting valved purged gas and dopant gas to the hollow tubular substrates.

113. The method of claim 109, further comprising connecting valved vacuum, dopant gas and purge gas ports to the chamber.

114. The method of claim 109, wherein providing the silica particle providers comprises providing burners mounted near walls of the chamber and pyrolyzing silicon compositions and generating silica powder.

115. The method of claim 109, wherein providing the silica particle providers comprises providing silica powder injectors near walls of the chamber.

116. The method of claim 109, wherein providing the second movers further comprise providing rotation and translation mechanisms connected to the support and rotating and translating the substrates in the chamber.

117. The method of claim 109, wherein providing the first mover further comprises providing independent adjustment and support mechanisms connected to the support which is connected to the rotation and translation mechanisms, and further comprising providing plural adjusters connected to the independent rotation and support mechanisms and moving the plural substrates and rotating them with respect to each other as the independent rotation and support mechanisms rotate and translate the substrates within the chamber.

118. The method of claim 109, further comprising providing heat controls connected to the heaters and increasing temperature within the chamber to vitrification temperatures and vitrifying and densifying the preforms in the chamber.

119. The method of claim 109, wherein the chamber, the at least one substrate and the preform are vertically oriented, and wherein the particle providers provide particles from cylindrical side areas of the chamber.

120. The method of claim 119, further comprising the providing a preform melting chamber below the preform forming chamber, and providing a movable shelf separating the preform forming chamber and the preform melting chamber, providing heaters adjacent walls of the preform melting chamber and providing valved ports connected to the preform melting chamber for providing gas delivery, gas venting, vacuum and dopants, and providing multiple heating zones in the chambers, and further comprising providing a rotating and pulling assembly connected to the preform melting chamber and withdrawing a fused silica member from the preform chamber.

121. The method of claim 120, further comprising providing a plasma surface removal unit positioned below the rotating and pulling assembly and finishing a surface of the fused silica member.

122. The method of claim 120, further comprising providing a plate and bar forming chamber, providing an input connected to the rotating and pulling assembly and withdrawing the fused silica member directly into the plate and bar forming chamber.

123. A fused silica producing method, comprising providing a fused silica chamber providing silica particle providers connected thereto and providing silica particles within the chamber, providing heaters within the chamber heating the particles and fusing the particles, providing a crucible within the chamber, collecting the heated and fused particles in the crucible, providing heaters connected to the crucible, heating and fusing the silica particles in the crucible, providing a valved dopant gas supplier connected to the crucible and supplying dopant gas to fused particles within the crucible, providing a melting zone connected to the crucible for delivering molten fused silica from the crucible, providing a forming member positioned below the melting zone, controlling flow of the molten fused silica over the forming member, and providing a purge gas connection to the forming member and introducing a purge gas in a middle of the molten flow, connecting a plate and bar forming chamber to an output of the fused silica chamber and directly receiving a fused silica output there from.



124. The method of claim 123, further comprising providing an electrical field generator, providing inner electrodes positioned beneath the forming body and outer electrodes positioned adjacent the flow and passing an electric field through the molten fused silica.

125. The method of claim 123, further comprising providing a second crucible positioned below the melting zone of the first crucible and receiving molten fused silica, providing a valved dopant gas inlet connected to the second crucible and introducing dopant gas into molten fused silica in the second crucible.

126. A quartz member production method comprising providing a plate/bar fabrication vacuum chamber providing a plurality of valved vacuum ports, gas inlet ports, vent ports, and a fused silica feed material introduction port, providing resistance or RF heating from heaters connected through a plurality of feedthroughs, providing a crucible made from graphite, silicon carbide, ceramic material, metal or metal alloys, receiving the feed material from the feed port, softening and solidifying the material, providing a plurality of ultrasound generators in contact with the crucible, promoting proper mixing and outgassing of the material, providing additional vacuum ports placed above the softened material and removing any gas bubbles.

127. The method of claim 126, wherein providing the fabrication chamber provides a plurality of chambers.

128. A method of producing fused silica fiber optic preforms, comprising providing a chamber, providing a plurality of substrates within the chamber, relatively rotating the plurality of substrates with respect to each other in the chamber, heating the chamber and the substrates, directing silica particles inward in the chamber toward the substrates, fusing silica particles on the substrates, and sticking particles to particles held on the substrates and forming porous silica preforms on the substrates, and relatively moving the substrates and preforms in the chamber.

129. The method of claim 128, wherein the providing of silica particles comprises generating silica particles with pyrolysis of silica particle precursors from wall-mounted burners.

130. The method of claim 128, wherein the providing of silica particles further

comprises providing silica particle streams toward the substrate and preform.

131. The method of claim 130, further comprising providing dopant gases to the chamber and through the substrate, and providing purge gas to the chamber and through the substrate, and venting and removing gases from the chamber.

132. The method of claim 128, wherein the moving comprises relatively rotating and translating the substrates and preforms within the chamber.

133. The method of claim 128, further comprising stopping the providing of particles, increasing heat on the preforms, and densifying and vitrifying the preforms.

134. The method of claim 133, further comprising depositing second layers of fused silica on the densified and vitrified silica preforms.

135. The method of claim 128, further comprising providing doped or undoped silica cores on the substrates and depositing doped or undoped cladding layers on the silica cores.

136. A method for forming a fused silica member, comprising providing an elongated chamber, providing a pressure control connected to the chamber, controlling pressure in the chamber, providing at least one collector in the chamber, providing silica particle providers in the chamber, supplying silica particles in the chamber and directing the silica particles toward the collector.

137. The method of claim 136, wherein the providing of the collector comprises providing at least one substrate in the chamber, providing at least one heater connected to the chamber for supplying heat to the substrate and to the chamber and for directing heat to silica particles for softening surfaces of the particles, providing a rotation assembly mounted on the chamber and connected to the at least one substrate, relatively rotating the substrate with respect to the chamber, sticking the heated particles to the substrate, forming a porous preform around the substrate and sticking the heated particles to a surface of the preform.

138. The method of claim 137, wherein the providing of the pressure control comprises providing at least one reduced pressure port in the chamber and venting and withdrawing gas.

139. The method of claim 138, further comprising at least one inlet port in the chamber and introducing purgant, dopant or oxidant gas into the chamber.

140. The method of claim 139, wherein the providing of the substrate comprises providing a hollow and porous substrate, and further comprising providing a substrate gas inlet connected to the substrate, and introducing purgant or dopant gas into the substrate and flowing the gas out through the porous substrate and through the preform on the substrate.

141. The method of claim 137, wherein the providing of at least one heater comprises providing at least one radiant heater in the chamber and directing heat to the substrate, the preform and the silica particles in the chamber.

142. The method of claim 137, wherein the providing of at least one heater comprises providing a radio frequency heater in the chamber, and directing heat to the substrate, the preform and the particles in the chamber.

143. The method of claim 137, wherein the providing of at least one heater comprises connecting a substrate heater to the substrate.

144. The method of claim 137, wherein the providing of at least one heater comprises providing plural heaters in the chamber and heating plural heat zones along the elongated chamber.

145. The method of claim 137, further comprising providing a translation mechanism connected to the chamber and the substrate and relatively translating the substrate with respect to the chamber.

146. The method of claim 137, wherein the providing of at least one substrate comprises providing plural parallel substrates mounted in the chamber, and wherein the providing rotation assembly further comprises multiple rotator connectors and relatively rotating the substrates with respect to each other substrate.

147. The method of claim 137, wherein the providing of silica particle providers comprises providing burners, introducing and pyrolyzing compounds in the chamber, and

providing the silica particles in the chamber.

148. The method of claim 137, wherein the providing of silica particle providers comprises providing silica powder stream injectors in the chamber and directing preformed silica powder toward the substrate and preform.

149. The method of claim 137, wherein the providing of the elongated chamber comprises providing a vertical elongated chamber and providing the at least one substrate comprises providing a vertical substrate within the chamber.

150. The method of claim 149, wherein the providing of the rotation assembly further comprises providing a substrate support at a top of the chamber, and wherein the providing of at least one heater further comprises providing at least one heater for providing increased heat near a bottom of the chamber, and softening and flowing fused silica from the preform.

151. The method of claim 150, wherein the providing of at least one substrate further comprises providing an enlarged lower end and flowing softened fused silica from an outer surface of the preform and around the enlarged lower end.

152. The method of claim 150, further comprising providing a rotating and pulling mechanism near a lower end of the chamber, and rotating and pulling the softened fused silica from the chamber.

153. The method of claim 152, wherein the softened and fused silica is pulled from the chamber as a tube.

154. The method of claim 152, wherein the softened and fused silica is pulled from the chamber as a rod.

155. The method of claim 152, wherein providing the at least one heater further comprises providing a resistance heater connected to the substrate and softening fused silica in the preform adjacent the substrate.

156. The method of claim 150, further comprising providing at least one divider partially extending across the chamber toward the substrate and the preform and separating an

upper part of the chamber from a lower part of the chamber.

157. The method of claim 156, further comprising adjusting the divider.

158. The method of claim 156, further comprising adjusting the divider in and out across the chamber.

159. The method of claim 156, further comprising adjusting the divider upward and downward along the chamber.

160. The method of claim 156, further comprising providing a first gas vent, providing a first vacuum port and providing a first dopant inlet connected to the chamber above the divider.

161. The method of claim 160, further comprising providing a gas delivery system, providing a second gas vent, providing a second vacuum port and providing a second dopant inlet connected to the chamber below the divider.

162. The method of claim 158, further comprising moving the divider between opened and closed positions and extending the divider inward to near the substrate in the closed position, wherein the silica powder providers are positioned above the divider, growing the preform above the divider, wherein the providing of at least one heater comprises providing at least one heater for increasing heating of the substrate above the divider, and wherein the divider in the opened position allows passage of the preform through the divider, whereby when the divider is moved to the opened position and the at least one heater increases temperature of the substrate above the divider, a portion of the preform near the substrate softens, allowing the preform to slide downward on the substrate and moving the preform from the upper part of the chamber to the lower part of the chamber.

163. The method of claim 151, further comprising providing electrodes near the softened silica, providing an electric field generator connected to the electrodes, and providing an electric field in the softened silica.

164. The method of claim 163, further comprising providing at least one of the electrodes on one side of the softened silica, providing at least one other of the electrodes on an

opposite side of the softened silica, and providing the electric field through the softened silica.

165. The method of claim 163, wherein the flowing of the softened silica from the preform comprises forming a tubular bubble and the providing the electrodes comprises providing the at least one of the electrodes outside of the tubular bubble, and providing the at least one other of the electrodes within the tubular bubble.

166. The method of claim 164, wherein the providing of electrodes comprises providing concentric ring electrodes.

167. The method of claim 151, further comprising providing a second chamber having a crucible tray, receiving the softened silica from the first chamber in the in the crucible tray, and heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

168. The method of claim 167, further comprising providing ultrasound generators in the second chamber adjacent the crucible tray and outgassing gas from the softened reformed fused silica.

169. The method of claim 168, further comprising providing additional vacuum ports near the crucible tray and removing gases outgassed from the softened reformed fused silica.

170. The method of claim 136, wherein the providing of silica particle providers comprises providing the streams in an upper part of the chamber and directing particles inward into a mass of particles, providing resistive, radio frequency, plasma or other heaters, heating particles and softening surfaces of the particles in the mass, and wherein the providing of at least one collector comprises providing a first heated crucible positioned with respect to the mass of particles, collecting softened particles and agglomerations of softened particles in the first heated crucible, providing a lower throat with a heater, and softening, fusing and flowing fused silica from the first crucible.

171. The method of claim 170, further comprising providing a flow director mounted beneath the lower heated throat, and directing flow of the flowing fused silica as a tubular or solid member having round, rectangular or polygonal cross-section.

172. The method of claim 171, further comprising connecting a dopant injector to the flow director and supplying dopant to the flowing fused silica.

173. The method of claim 172, further comprising providing a second crucible positioned below the heated throat, receiving flowing fused silica, providing a dopant injector in the second crucible, and injecting dopant in the fused silica in the second crucible.

174. The method of claim 173, further comprising providing a second chamber, providing a crucible tray in the second chamber, receiving the softened silica from the first chamber in the crucible tray, heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

175. The method of claim 174, further comprising providing ultrasound generators in the second chamber adjacent the crucible tray and outgassing gas from the softened reformed fused silica.

176. The method of claim 175, further comprising providing additional vacuum ports near the crucible tray and removing gases outgassed from the softened reformed fused silica through the additional vacuum ports.

177. A method for forming a fused silica member, comprising providing of an elongated chamber, providing a pressure control connected to the chamber, and controlling pressure in the chamber, providing at least one collector mounted in the chamber, providing silica particle providers connected to the chamber and supplying silica particles in the chamber and directing the silica particles toward the collector, providing at least one heater connected to the chamber and supplying heat to the collector, to the chamber and to the silica particles, softening surfaces of the particles and sticking the particles on the substrate and on heated particles on the substrate, forming a porous preform around the substrate and sticking the heated particles to a surface of the preform and thereby collecting the particles with softened surfaces with the collector.

178. The method of claim 177, wherein providing the collector comprises providing at

least one substrate in the chamber, providing a rotation assembly mounted on the chamber and providing connection to the at least one substrate and relatively rotating the substrate with respect to the chamber.

179. The method of claim 178 wherein providing the pressure control comprises providing at least one reduced pressure port in the chamber and venting and withdrawing gas.

180. The method of claim 178, further comprising providing the at least one inlet port in the chamber and introducing purgant, dopant or oxidant gas into the chamber.

181. The method of claim 178, wherein providing the substrate comprises providing at least one hollow and porous substrate, and further comprising connecting a substrate gas inlet to the substrate and introducing purgant or dopant gas into the substrate and flowing the gas out through the porous substrate and through the preform on the substrate.

182. The method of claim 178, wherein providing the at least one heater comprises providing at least one radiant heater in the chamber and directing heat to the substrate, the preform and the silica particles in the chamber.

183. The method of claim 178, wherein the providing of at least one heater comprises providing a radio frequency heater in the chamber and directing heat to the substrate, the preform and the particles in the chamber.

184. The method of claim 178, wherein providing the at least one heater comprises connecting a substrate heater to the substrate.

185. The method of claim 178, wherein providing the at least one heater comprises providing plural heaters in the chamber and heating plural heat zones along the elongated chamber.

186. The method of claim 178, further comprising connecting a translation mechanism to the chamber and the substrate and relatively translating the substrate with respect to the chamber.

187. The method of claim 178, wherein providing the at least one substrate comprises



providing plural parallel substrates mounted in the chamber, and wherein providing the rotation assembly further comprises providing multiple rotator connectors and relatively rotating the substrates with respect to each other substrate.

188. The method of claim 178, wherein providing the silica particle providers comprise providing burners for introducing and pyrolyzing compounds in the chamber and thereby providing the silica particles in the chamber.

189. The method of claim 178, wherein providing the silica particle providers comprise providing silica powder stream injectors in the chamber and directing preformed silica powder toward the substrate and preform.

190. The method of claim 178, wherein the elongated chamber is vertical and the at least one substrate is vertical within the chamber.

191. The method of claim 190, wherein providing the rotation assembly further comprises providing a substrate support at a top of the chamber, and wherein providing the at least one heater further comprises providing at least one heater for providing increased heat near a bottom of the chamber and softening and flowing fused silica from the preform.

192. The method of claim 191, wherein providing the substrate further comprises providing an enlarged lower end and flowing softened fused silica from an outer surface of the preform.

193. The method of claim 190, further comprising providing a rotating and pulling mechanism near a lower end of the chamber and rotating and pulling the softened fused silica from the chamber.

194. The method of claim 193, wherein the pulling the softened and fused silica from the chamber comprises pulling the silica as a tube.

195. The method of claim 193, wherein the pulling the softened and fused silica from the chamber comprises pulling the silica as a rod.

196. The method of claim 193, wherein providing the at least one heater further

comprises providing a resistance heater connected to the substrate and softening fused silica in the preform adjacent the substrate.

197. The method of claim 193 further comprising providing at least one divider partially extended across the chamber toward the substrate and the preform and separating an upper part of the chamber from a lower part of the chamber.

198. The method of claim 197, further comprising adjusting the divider in and out across the chamber.

199. The method of claim 197, further comprising adjusting the divider upward and downward along the chamber.

200. The method of claim 197, further comprising providing a first gas vent, a first vacuum port and a first dopant inlet connected to the chamber above the divider.

201. The method of claim 200, further comprising providing a gas delivery system, a second gas vent, a second vacuum port and a second dopant inlet connected to the chamber below the divider.

202. The method of claim 201, further comprising moving the divider between opened and closed positions and extending the divider inward to near the substrate in the closed position, wherein the silica powder providers are positioned above the divider and growing the preform occurs above the divider, wherein providing the at least one heater comprises providing at least one heater for increasing heating of the substrate above the divider, and wherein moving the divider to the opened position allows passage of the preform through the divider, whereby when the divider moves to the opened position and the at least one heater increases temperature of the substrate above the divider, a portion of the preform near the substrate softens, allowing the preform to slide downward on the substrate, moving the preform from the upper part of the chamber to the lower part of the chamber.

203. The method of claim 193, further comprising providing electrodes near the softened silica and connecting an electric field generator to the electrodes and providing an

electric field in the softened silica.

204. The method of claim 203, further comprising providing at least one of the electrodes on one side of the softened silica, and providing at least one other of the electrodes on an opposite side of the softened silica and providing an electric field through the softened silica.

205. The method of claim 204, wherein flowing the softened silica from the preform comprises forming a tubular bubble, and providing the at least one of the electrodes outside of the tubular bubble, and providing the at least one other of the electrodes within the tubular bubble.

206. The method of claim 205, wherein providing the electrodes comprise providing concentric ring electrodes.

207. The method of claim 193, further comprising providing a second chamber providing a crucible tray and receiving the softened silica from the first chamber in the crucible tray, and providing at least one second chamber heater in the second chamber and heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

208. The method of claim 207, further comprising providing ultrasound generators in the second chamber adjacent the crucible tray and outgassing gas from the softened reformed fused silica.

209. The method of claim 208, further comprising providing additional vacuum ports near the crucible tray and removing gases outgassed from the softened reformed fused silica.

210. The method of claim 136, wherein providing the particle providers is in an upper part of the chamber directing the particles inward into a mass of the particles, and wherein providing the at least one heater comprises providing a resistive, radio frequency, plasma or other heater and heating particles and softening surfaces of the particles in the mass of particles, and wherein providing the collector comprises providing a first heated crucible positioned with respect to the mass of particles and collecting softened particles and agglomerations of softened particles from the mass, the first heated crucible having a lower throat with a heater for softening,

fusing and flowing fused silica from the first crucible.

211. The method of claim 210, further comprising providing a flow director mounted beneath the lower throat and directing of flow of the flowing fused silica as a tubular or solid member having round, rectangular or polygonal cross-section.

212. The method of claim 211, further comprising connecting a dopant injector to the flow director and supplying dopant to the flowing fused silica.

213. The method of claim 212, further comprising providing a second crucible positioned below the heated throat and receiving flowing fused silica in the second crucible, a dopant providing injector in the second crucible and injecting dopant in the fused silica in the second crucible.

214. The method of claim 210, further comprising providing a second chamber having a crucible tray and receiving in the tray the softened silica from the first chamber, providing at least one second chamber heater in the second chamber and heating the fused softened silica and reforming the silica in a desired form in the crucible tray.

215. The method of claim 214, further comprising providing ultrasound generators in the second chamber adjacent the crucible tray and outgassing gas from the softened reformed fused silica.

216. The method of claim 215, further comprising providing additional vacuum ports near the crucible tray and removing gases outgassed from the softened reformed fused silica.

217. The apparatus of claim 1, wherein the substrates comprise long hollow porous tubes.

218. The apparatus of claim 1, wherein the substrate is a hollow porous tube and the substrate heater is a hollow porous tube made from same material.

219. The apparatus of claim 1, wherein the substrate is a hollow porous tube and the substrate heater is a hollow porous tube made from different material.

220. The apparatus of claim 1, wherein the substrate is a hollow porous tube made

from silica, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

221. The apparatus of claim 1, wherein the substrate is a hollow tube made from silica, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

222. The apparatus of claim 1, wherein the substrate is a hollow porous tube of undoped synthetic fused silica or natural quartz.

223. The apparatus of claim 1, wherein the substrate is a hollow porous tube of doped synthetic fused silica or natural quartz.

224. The apparatus of claim 1, wherein the substrate is a non-hollow porous tube of doped synthetic fused silica or natural quartz.

225. The apparatus of claim 1, wherein the substrate is a non-hollow porous tube of undoped synthetic fused silica or natural quartz.

226. The apparatus of claim 1, wherein the substrate is a porous rod of undoped synthetic fused silica or natural quartz.

227. The apparatus of claim 1, wherein the substrate is a porous rod of doped synthetic fused silica or natural quartz.

228. The apparatus of claim 1, wherein the substrate is a non-porous rod of doped synthetic fused silica or natural quartz.

229. The apparatus of claim 1, wherein the substrate is a porous rod of undoped synthetic fused silica or natural quartz.

230. The apparatus of claim 1, wherein the substrate heater is a hollow porous or non porous tube made from doped or undoped synthetic fused silica or natural quartz, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

231. A hot substrate apparatus for fused silica deposition comprising a hollow body

tube, rod, plate, made from doped or undoped synthetic fused silica, natural quartz, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

232. The apparatus of claim 231, wherein the hollow body tube is comprised of a porous tube, rod or plate.

233. The apparatus of claim 231, wherein the hollow body tube is comprised of a non-porous tube, rod or plate.

234. The apparatus of claim 231, wherein the substrates comprise long hollow porous tubes.

235. The apparatus of claim 231, wherein the substrate is a hollow porous tube and the substrate heater is a hollow porous tube made from same or different material.

236. The apparatus of claim 231, wherein the substrate is a hollow porous tube made from silica, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

237. The apparatus of claim 231, wherein the substrate heater is a hollow tube made from silica, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.

238. The apparatus of claim 231, wherein the substrate is a hollow porous or non-porous tube of doped or undoped synthetic fused silica or natural quartz.

239. The apparatus of claim 231, wherein the substrate is a porous or non-porous rod of doped or undoped synthetic fused silica or natural quartz.

240. The apparatus of claim 231, wherein the substrate heater is a hollow porous or non porous tube, rod, plate any other shape, and has constant or variable cross section over its length, width and height, made from doped or undoped synthetic fused silica or natural quartz, ceramic, graphite, silicon carbide, boron nitride, metal, metal alloys, other suitable substrate materials and their combination thereof.